Influence of silicon, nitrogen and molybdenum doses on the production of bean pods

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Abstract**—** *The snap beans is greatly appreciated and consumed by Brazilians, and the snap beans commercial seeds are divided into indeterminate growth habit and determined. Farmers most often plant indeterminate growth habit bean-pod, so the fertilizer recommendations are for this habit. Due to the availability of determinate growth habit cultivars, it is necessary to study the nutrition area, because they have the shortest cycle, flowering and pod production in concentrated period, smaller spacing and planting densities with greater influence in the population by ha. The study aimed to evaluate the snap bean growth given in the search response with increased productivity positively due to the use of silicon as well as the rational use of Nitrogen and Molybdenum. The experiment was design on track and installed with subplots and two replications, using treatments with and without foliar application of 5% of eucalyptus ash, four nitrogen doses 0, 50, 100 and 150 kg N / ha and four molybdenum doses in foliar application 0, 30, 60 and 90 g Mo / ha. Nitrogen and molybdenum treatments responded with a yield and quality increase, allowing adjusting of quadratic equations regression and to recommend if the farmer does not use molybdenum, the nitrogen dose of 79.2 kg in coverage application. For molybdenum and nitrogen, according to the results obtained, the doses of 35g Mo / ha and 130 kg N / ha in coverage are recommended in coverage application. The silicon, applied through eucalyptus ash, did not respond in production.*

***Keywords—* *Phaseolus vulgaris, mineral nutrition, cv. Novirex, pod, nitrogen fertilizer, sodium molybdate*.**

I. INTRODUCTION

The bean-pod culture has its importance because it is widely appreciated and consumed by the Brazilian, being among the vegetables more commercialized in the central of supply. From the same botanical species of the common bean, the commercial seeds of the bean-pod are divided in relation to the habit of growth in indeterminate and determined. The majority of the farmers planted bean pods with an indeterminate growth habit (climber) in crop rotation with plants that need to be tutored, such as tomatoes and cucumbers, so the fertilization recommendations found in the literature are for this habit of growth. With the availability of cultivars of determined growth habit, it is necessary the study in the area of nutrition, as they present the shorter cycle, flowering and pod production in the concentrated period, smaller spacing and higher planting densities, with influence on the production per hectare. Different from the traditional cultivars of indeterminate habit, we seek the knowledge for the bean-pod of determined habit, in such a way, that the farmer can conduct his crops with rational and economic fertilization. They can thus achieve better environmental preservation and better utilization of nutrients and thus greater productivity.

The induction of resistance, through the possible activation of defense mechanisms existing in plants in response to biotic or abiotic agents, becomes an important strategy in the pursuit of sustainability. Thus, the silicon can act as an illicitor of the resistance process induced in plants according to [1]. Possibly some illiciting agents induce defense responses in plants, such as changes in cellular, physiological and morphological structure. An interesting source of silicon is eucalyptus ash, which has an average of 16.9% of SiO2, among other nutrients, being important in the vegetative development of plants, acting as a promoter of potato growth [2]; [3]. However, it is important to note that the [4] recommends for the indeterminate growth habit bean the use of 700 kg / ha of NPK formulation 4-14-8 or 350 kg / ha of the formulated 8-28-16, twenty days after emergence of the seedlings, it should be fertilized with 200 kg / ha of ammonium sulphate or 100 kg / ha of urea under cover and at the same time spray the plants with 100 g / ha of sodium molybdate to stimulate the fixation of atmospheric N.

Although N is incorporated into numerous plant essential compounds, it is largely present in proteins. N has two general functions: establishments and maintenance of photosynthetic capacity; development and growth of reproductive drains [5]. It is also an important structural component of macromolecules and a constituent of enzymes, besides acting as precursor of plant hormones, chlorophyll and cytochrome [6].

The main functions of molybdenum in plants are related to nitrogen metabolism. These functions are linked to the action or enzymatic activation, more precisely, with respect to the enzymes nitrogenase and nitrate reductase [7].

In the bean-pod was observed by [8] the positive response in the production in the use of nitrogen in coverage. However it is in common bean culture that more studies on nitrogen and molybdenum are presented, [9] reported that the relative index of chlorophyll in the leaves of the bean was increased by the application of N in cover and the Mo via foliar. The application of N in cover provided an increase in grain yield of the bean only when combined with the supply of Mo via foliar. The supply of 80 g ha-1 of Mo via leaf increased the efficiency of N utilization by bean, according to [10], both in the presence and absence of nitrogen in sowing or cover, the increase of the molybdenum dose up to 80 g ha-1 increases the number of pods per plant and grain yield of the bean.

In relation to molybdenum sources [11] observed that sodium molybdate or ammonium molybdate can be used indifferently for leaf application in common bean. With regard to the installment and application time [12] concluded that the foliar application of Mo, starting at 15 and 20 days after emergence in a single or split dose, increases grain yield in summer-fall cultivation. In winter-spring cultivation, productivity increases with Mo applied between 15 and 30 days after emergence, in a single or split dose. Thus, the objective of this work was to evaluate the influence of silicon application and different nitrogen and molybdenum doses on the economic production of the bean-pod of determined growth.

II. METHODOLOGY

The work was carried out at the Lambari Experimental Farm of the Agricultural Research Company of Minas Gerais (EPAMIG) located at the south of Minas Gerais, at an altitude of 895 meters, latitude 21 ° 58 'S and longitude 45 ° 23' W. The design experimental study was in the range with subplots and two replications. The treatments were with and without application of eucalyptus ash, four nitrogen rates in coverage (0, 50, 100 and 150 kg of N / ha) and four doses of molybdenum via leaf (0, 30, 60 and 90 g Mo / there is). Cover fertilization was performed 20 days after emergence (20 DAE), using as urea source (44% of N).

The application of 5% eucalyptus ash was foliar via weekly, starting 7 days after emergence, which was diluted in water and, after being fired, was sprayed on the plants until runoff [2].

The molybdenum foliar application was performed at 14 DAE, using sodium molybdate (39% Mo) as the source. For greater precision in the dosages the application was made with a manual costal spray, working at a height of 0.5 m in relation to the ground level. The volume of the syrup used was between 300 and 400 l / ha, adding 1% (v / v) of adhesive spreader.

The plots had spacing of 0.5 m between rows and sowing density of 12-13 seeds per linear meter. The plots were constituted by four rows of 5.0 m in length, making a total area of 10.0 m2. As a useful area, the two central rows (5.0 m2) were considered. At sowing the doses of 50 kg N / ha + 150 kg P2O5 / ha + 50 kg K2O / ha were used. The other cultural treatments were those normally used in the culture that received the complementary irrigation.

The final stand and weight of commercial and non-commercial pods per plot were evaluated. Pods less than 10 cm in length, those of 10-15 cm less than 7 mm in diameter and all fibrous were considered non-commercial. The remaining pods were considered commercial, with only one harvest.

The yield was evaluated by weighing the pods of the useful plot, and only the commercial pods were evaluated and presenting the result in kg / ha;

The data were initially submitted to analysis of variance based on [13], using the SISVAR program [14]. In cases of significance in the source of cultivar variation, the Scott-Knott test is used to compare the means. In cases of significance for doses, regression analysis and selection of the appropriate mathematical model to express the relationship between the variables [15].

The variable cost was carried out to show the economic feasibility of the production of bean-pod of growth determined as a function of increasing doses of nitrogen and molybdenum, seeking the economic maximum point aiming to orient the producer to the decision-making with respect to the culture aiming at greater profit.

III. RESULTS AND DISCUSSION

The present experiment was a continuation of two other experiments conducted in 2010 and 2011 [16], when it was observed that nitrogen responded in a growing way up to 90 kg.ha-1, in the discussion of the mentioned work the need to apply molybdenum was also observed in the 14 days after emergence (DAE), since the cultivar (Table 1). In the present study, the effect of molybdenum on the formation of molybdenum in the presence of molybdenum in the presence of molybdenum was observed. (2008) where they report that the application of Mo can be performed efficiently between 14 and 28 DAE.

TABLE 1
MEANS OF TOTAL BEAN POD YIELD. DOES. EXP. DE LAMBARI - MG, BRAZIL,2011.

Average Silício	Average Treatments (kg / ha)
With Molibdênio	6.484
Without Molibdênio	6.669
0	6.242
30	7.155
60	6.700
90	6.209

In the obtained results there was no significant response for silicon and molybdenum when applied to the total production (Table 1). The productivity results were not expected due to the fact that the planting carried out in October 2011 faced low temperatures associated with rainfall, which proved to be a meteorological condition unfavorable to the crop, negatively influencing the production. Regarding nitrogen, the response was significant, which we observed in Figure 1, the regression curve for this variation factor, our results resemble those found by [8], where they observed an increase in yield due to nitrogen fertilization on the pods. When we derive the equation at 1 ° and equate to zero we obtain the maximum total production for the dose of 136.31 kg.ha-1 of nitrogen in coverage, the economic dose being 90% of this value which is 122.68 kg.ha- 1 of nitrogen. In this experiment, it was possible to determine the point of contact with the soil, and to determine the amount of nitrogen used in the experiment [16], which indicated the use of 90 kg.ha-1 of nitrogen. of maximum production and maximum economic production.

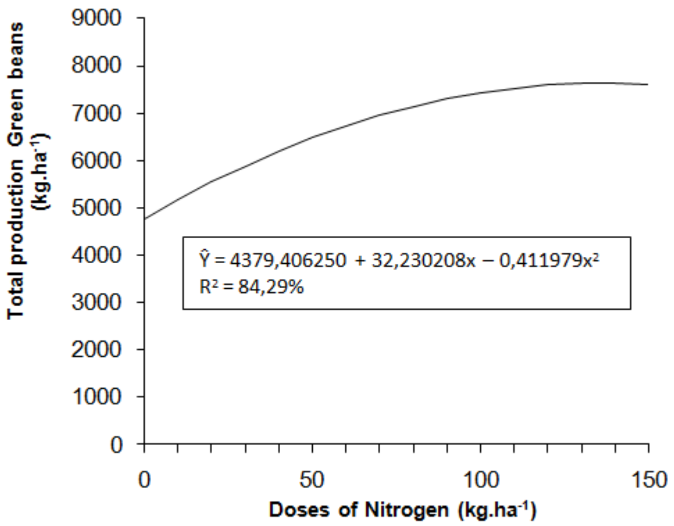

FIGURE 1- Graph of the regression equation as a function of nitrogen rates and total bean production. Lambari – MG, Brazil, 2011.

When we evaluated the commercial production we observed that silicon did not present a significant response according to table 2, and we obtained significant responses for nitrogen, molybdenum and nitrogen interaction with molybdenum.

TABLE 2
RESPONSE OF COMMERCIAL BEAN POD PRODUCTION FOR SILICON APPLICATION.

Average Silício	Average Treatments (kg / ha)
With Molibdênio	4.469
Without Molibdênio	4.594

Regarding the regression equation of nitrogen, figure 2 shows a quadratic response where the maximum and economical dose point is obtained. In figure 3 we observe the regression equation of the molybdenum also adjusted to a 2° Degree equation. In this way we can study the point of maximum production and the economic point that for this equation is 39.11 mg of molybdenum / ha. The point of maximum economic return with 90% of the dose at the maximum production point will be 35.20g Mo.ha-^{1}. The response curves presented in figure 4 represent the responses to nitrogen doses within each dose of molybdenum. It can be observed that the bean pods responded to nitrogen at the dose 0 g Mo.ha-1 reaching the maximum production value at the dose of 88.04 kg of N.ha-1 and the maximum economic point of 79.23 kg of N.ha-^{1}, the dose response of 30 g Mo.ha-^{1} was 135.51 kg of N.ha-1 and the economic maximum point of 121.96 kg of N.ha-^{1}, while the doses of 60 and 90 g Mo.ha-1 the maximum points are outside the range studied. The results corroborate [9], when the authors conclude that molybdenum increases nitrogen efficiency, but in the present experiment, nitrogen increased production even without the use of molybdenum. In the experiment by [16], there was no significant difference in the use of molybdenum due to the fact that the range of nitrogen doses was 0 and 90 kg of N.ha-1. The effect of fertilization with molybdenum when we use higher doses of nitrogen is positive.

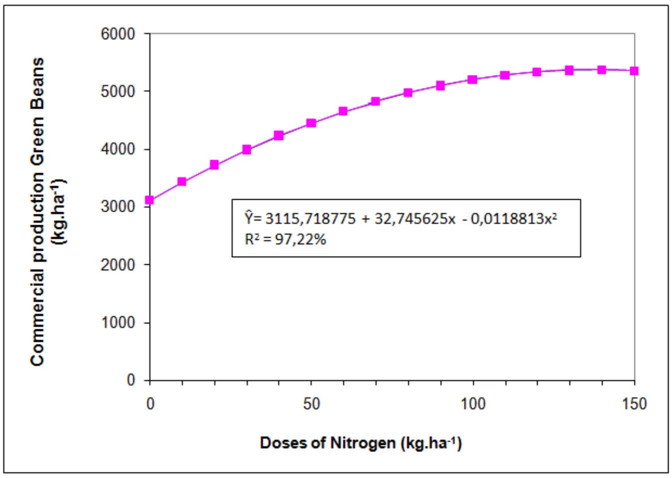

FIGURE 2- Graph of the regression equation as a function of nitrogen rates and commercial production of pod beans. Lambari - MG 2011

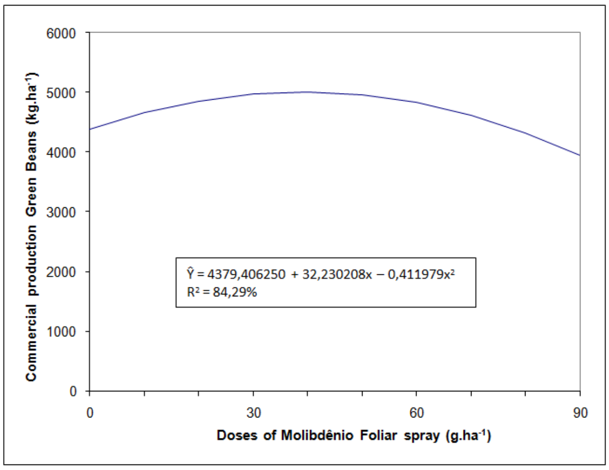

FIGURE 3- Graph of the regression equation as a function of molybdenum doses and commercial bean pod production. Lambari - MG 2011

In the study of economic viability the advantage of studying commercial production is to use the data of how much can be commercialized effectively, the increase in the number of pods does not necessarily come with the desired quality, causing non-standard pods. The maximum point of production occurs with the dose of 138.0 kg of nitrogen per hectare and the economic dose with 130.0 kg of N, obtained through Table 3, where the nitrogen doses were applied and using the equations, if the production that multiplied by the value of US$ 1.92 of the pod data obtained in the Ceasa of Belo Horizonte on July 23, 2012, access day 24 of 2012, we obtained the production value [17].

TABLE 3
STUDY OF THE POINT OF MAXIMUM ECONOMIC RETURN WITH RELATION TO NITROGEN UTILIZATION AND BEAN POD PRODUCTION LAMBARI - MG, BRAZIL, 2012

Doses of N	Production Pod (kg/ha)	Recipe Pod (R$)	Nitrogen Cost (R$)	Economic return (R$)
128	5360,527	10292,21	455,68	9836,53
129	5362,737	10296,46	459,24	9837,21
130	5364,710	10300,24	462,80	9837,44
131	5366,446	10303,58	466,36	9837,21
132	5367,944	10306,45	469,92	9836,53
133	5369,204	10308,87	473,48	9835,39
134	5370,226	10310,83	477,04	9833,79
135	5371,011	10312,34	480,60	9831,74
136	5371,559	10313,39	484,16	9829,23
137	5371,868	10313,99	487,72	9826,26
138	5371,940	10314,13	491,28	9822,84
139	5371,775	10313,81	494,84	9818,96
140	5371,371	10313,03	498,40	9814,63

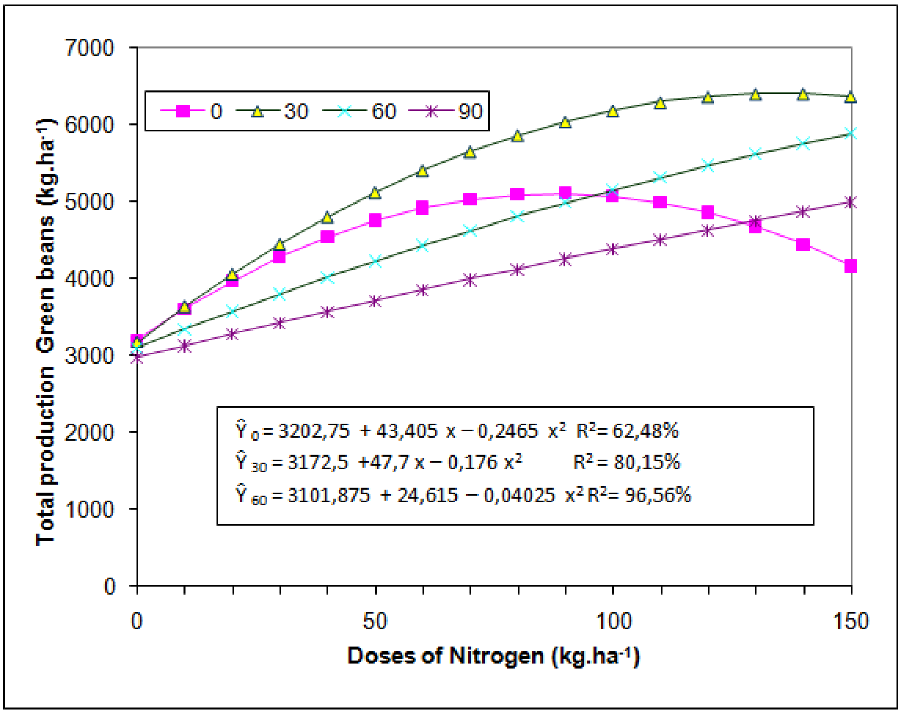

FIGURE 4 - Graphs of the equations as a function of the nitrogen doses inside the molybdenum doses, for commercial production of the bean pod. Lambari - MG 2011.

We discount the costs with the nitrogen whose source was the urea with price of $ 80.00 the bag of 50 kg. Due to the fact that the price of beans is high, the curiosity to verify if the point coincides with the usual 90.00%, showed that in this case the economic maximum point occurred with 94.21% as we can see in table 3. At point of the maximum return to each US$ 0.03 invested in nitrogen, there was a return of R $ 21.29 with the commercialization of the bean pod.

IV. CONCLUSION

If the farmer does not use molybdenum the maximum economic dose of N / ha was 79.2 kg in coverage.

With the use of molybdenum the maximum economic dose was 35 g Mo / ha and 130 kg of N / ha in coverage.

The silicon, applied via eucalyptus ash, did not respond in relation to the production.

The return at the maximum economic point with the sale of commercial beans was US$ 5.60 for each US$ 0.03 invested in nitrogen.

* **Dollar Price 3.84 (13 dec, 2018)**

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